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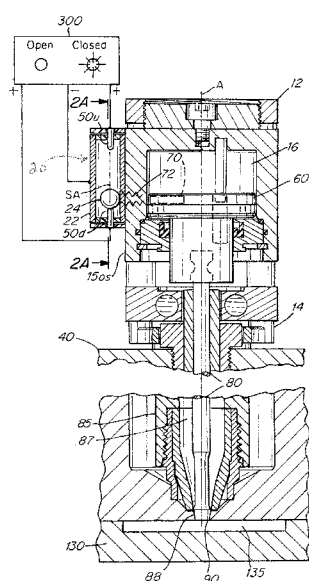


Fig. 2

(57) Abstract: An apparatus for detecting position of an actuator piston (60) and an interconnected valve pin (80) comprising: an actuator (10), a magnetic member (70) generating a magnetic field (72), a sensor (20) comprised of: a free floating body (24) comprised of one or more selected materials that are attracted to the magnetic field (72) and are electrically conductive, a guide (25) or a sensor housing (22) having one or more electrically conductive surfaces (21 is, 160, 170), first (50u) and second 50d) electrical contacts forming first circuit (220) and second circuit (210) electrical circuits with the free floating body and electrically conductive surfaces.



POSITION DETECTOR

RELATED APPLICATIONS

[001] The disclosures of all of the following are incorporated by reference in their entirety as if fully set forth herein: U.S. Patent No. 5,894,025, U.S. Patent No. 6,062,840, U.S. Patent No. 6,294,122, U.S. Patent No. 6,309,208, U.S. Patent No. 6,287,107, U.S. Patent No. 6,343,921, U.S. Patent No. 6,343,922, U.S. Patent No. 6,254,377, U.S. Patent No. 6,261,075, U.S. Patent No. 6,361,300 (7006), U.S. Patent No. 6,419,870, U.S. Patent No. 6,464,909 (7031), U.S. Patent No. 6,599,116, U.S. Patent No. 7,234,929 (7075US1), U.S. Patent No. 7,419,625 (7075US2), U.S. Patent No. 7,569,169 (7075US3), U.S. Patent Application Serial No. 10/214,118, filed August 8, 2002 (7006), U.S. Patent No. 7,029,268 (7077US1), U.S. Patent No. 7,270,537 (7077US2), U.S. Patent No. 7,597,828 (7077US3), U.S. Patent No. 8,328,549 (7096), U.S. Patent Application Serial No. 09/699,856 filed October 30, 2000 (7056), U.S. Patent Application Serial No. 10/269,927 filed October 11, 2002 (7031), U.S. Application Serial No. 09/503,832 filed February, 15, 2000 (7053), U.S. Application Serial No. 09/656,846 filed September 7, 2000 (7060), U.S. Application Serial No. 10/006,504 filed December 3, 2001, (7068), U.S. Application Serial No. 10/101,278 filed March, 19, 2002 (7070), U.S. patent publication no. 2009/0061034, International application publication no. WO 2014/025369, U.S. patent publication no. 2008/0211522 and international applications PCT/US2011/062099 and PCT/US2011/062096 and PCT/US2015/10270.

BACKGROUND OF THE INVENTION

[002] Injection molding systems using a variety of mechanisms that detect position of a piston or valve pin component of an actuator have been employed including systems such as disclosed in International application publication no. WO 2014/025369, U.S. patent publication no. 2009/0061034, U.S. patent publication no. 2008/0211522 in which a magnet is mounted to actuator piston and another element interacts with or detects a magnetic field generated by the magnet.

SUMMARY OF THE INVENTION

[003] In accordance with the invention there is provided an apparatus for detecting position of an actuator piston (60) and an interconnected valve pin (80) in an injection molding system (1), the apparatus comprising:

- an actuator (10) comprising an actuator housing (15) having an exterior surface (15os) and an interior bore (16) having an axis (SA),

- the actuator piston (60) being movable upstream and downstream (UD) along an axial path of travel (A) within the interior bore (16) of the actuator housing (15),

- a magnetic member (70) mounted to and movable with the actuator piston (60) along the axial path of travel (A) of the actuator piston within the interior bore (16), the magnetic member (70) generating a magnetic field (72),

- a sensor (20) comprised of:

- a free floating body (24) comprised of one or more selected materials that are attracted to the magnetic field (72) and are electrically conductive,

- a guide (25) or a sensor housing (22) having one or more electrically conductive surfaces (21is, 160, 170) that define an upstream to downstream path of travel for the free floating body (24) and are interconnected to a first source of electrical polarity (200i),

- the free floating body (24) being held by the magnetic member (70) in electrically conductive contact with the one or more electrically conductive surfaces (21is, 160, 170),

- the guide (25) or sensor housing (22) being mounted outside the interior bore (16) of the actuator housing (15) in an arrangement such that the free floating body (24) is attracted to the magnetic member (70) and follows movement of the piston (60) to which the magnetic member (70) is mounted by travelling along the upstream downstream path of travel of the free floating body (24),

- first (50u) and second (50d) electrical contacts being interconnected to a second source (200p) of electrical polarity that is opposite the polarity of the first source, the first and second electrical contacts being disposed respectively at first and second selected upstream and downstream positions along the path of upstream to downstream travel of the free floating body (24),

the first selected upstream position being selected such that the free floating body (24) comes simultaneously into electrically conductive engagement with the first electrical contact (50u) and one of the electrically conductive surfaces (21is, 160) to form a first circuit (220) when the free floating body is disposed in the selected upstream position along the upstream to downstream path of travel,

the second selected downstream position being selected such that the free floating body (24) comes simultaneously into electrically conductive engagement with the second electrical contact (50d) and one of the electrically conductive surfaces (21is, 170) to form a second circuit (210) when the free floating body is disposed in the selected downstream position along the upstream to downstream path of travel.

[004] The sensor housing can comprise a hollow tube (22) comprised of an electrically conductive material, the free floating body (24) being disposed within a channel (22i) of the tube having an interior electrically conductive surface (21is) with which the free floating body makes electrically conductive contact under magnetic force (72) exerted by the magnet (70) that is mounted on the piston (60).

[005] The guide or the sensor housing is typically mounted in relation to the actuator housing such that the magnetic member (70) attracts the free floating member (24) into electrically conductive engagement with the electrically conductive surface (160, 170) at least when the free floating member is disposed in either the selected upstream position or the selected downstream position.

[006] Preferably an observable signal is generated on formation of first and second circuits.

[007] The selected upstream position of the upstream to downstream path of travel typically corresponds to a followed position of the piston that is a position of maximum upstream travel of the piston and interconnected valve pin.

[008] The selected downstream position of the upstream to downstream path of travel typically corresponds to a followed position of the piston that is a position of maximum downstream travel of the piston and interconnected valve pin.

[009] The free floating member is preferably configured generally as a sphere.

[010] In another aspect of the invention there is provided a method of determining the position of a piston disposed within an actuator housing in an injection molding system, comprising operating an apparatus as described above to move the actuator piston between a gate closed position and an upstream position such that the first and second circuits are formed during the course of an injection cycle.

[011] In another aspect of the invention there is provided an injection molding system (1), comprising:

- a manifold (40), an injection molding machine having a barrel (3) that delivers injection fluid (7) to a fluid distribution channel (42) of the manifold (40), a mold (130, 131) forming a cavity (135),

- an actuator (10) comprising an actuator housing (15) having an exterior surface (15os) and an interior bore (16) having an axis (SA),

- the actuator piston (60) being movable upstream and downstream (UD) along an axial path of travel (A) within the interior bore (16) of the actuator housing (15),

- a magnetic member (70) mounted to and movable with the actuator piston (60) along the axial path of travel (A) of the actuator piston within the interior bore (16), the magnetic member (70) generating a magnetic field (72),

- a sensor (20) comprised of:

- a free floating body (24) comprised of one or more selected materials that are attracted to the magnetic field (72) and are electrically conductive,

- a guide (25) or a sensor housing (22) having one or more electrically conductive surfaces (21is, 160, 170) that define an upstream to downstream path of travel for the free floating body (24) and are interconnected to a first source of electrical polarity (200i),

- the free floating body (24) being held by the magnetic member (70) in electrically conductive contact with the one or more electrically conductive surfaces (21is, 160, 170),

- the guide (25) or sensor housing (22) being mounted outside the interior bore (16) of the actuator housing (15) in an arrangement such that the free floating body (24) is attracted to the magnetic member (70) and follows movement of the piston (60) to

which the magnetic member (70) is mounted by travelling along the upstream downstream path of travel of the free floating body (24),

first (50u) and second (50d) electrical contacts being interconnected to a second source (200p) of electrical polarity that is opposite the polarity of the first source, the first and second electrical contacts being disposed respectively at first and second selected upstream and downstream positions along the path of upstream to downstream travel of the free floating body (24),

the first electrical contact (50u) being arranged relative to the one or more electrically conductive surfaces (21is, 160, 170) such that the free floating body (24) comes simultaneously into electrically conductive engagement with the first electrical contact (50u) and one of the electrically conductive surfaces (21is, 160) to form a first circuit (220) when the free floating body is disposed in the selected upstream position along the upstream to downstream path of travel,

the second electrical contact (50d) being arranged relative to the one or more electrically conductive surfaces (21is, 160, 170) such that the free floating body (24) comes simultaneously into electrically conductive engagement with the second electrical contact (50d) and one of the electrically conductive surfaces (21is, 170) to form a second circuit (210) when the free floating body is disposed in the selected downstream position along the upstream to downstream path of travel.

[012] The sensor housing can comprise a hollow tube (22) comprised of an electrically conductive material, the free floating body (24) being disposed within a channel (22i) of the tube having an interior electrically conductive surface (21is) with which the free floating body makes electrically conductive contact under magnetic force (72) exerted by the magnet (70) that is mounted on the piston. (60).

[013] The guide or housing can be mounted in relation to the actuator housing such that the magnetic member (70) attracts the free floating member (24) into electrically conductive engagement with the electrically conductive surface (21is, 160, 170) of the tubular wall when the free floating member is disposed in either the selected upstream position or the selected downstream position.

[014] An observable signal is generated on formation of first and second circuits.

[015] The selected upstream position of the upstream to downstream path of travel typically corresponds to a followed position of the piston that is a position of maximum upstream travel of the piston and interconnected valve pin.

[016] The selected downstream position of the upstream to downstream path of travel corresponds to a followed position of the piston that is a position of maximum downstream travel of the piston and interconnected valve pin.

[017] In another aspect of the invention there is provided a method of determining the position of a piston disposed within an actuator housing in an injection molding system comprising operating a system as described above to move the actuator piston between a gate closed position and an upstream position such that the first and second circuits are formed during the course of an injection cycle.

[018] In another aspect of the invention there is provided an apparatus for detecting position of an actuator piston and an interconnected valve pin in an injection molding system, the apparatus comprising:

- an actuator comprising an actuator housing having an exterior surface and an interior bore having an axis,

- the actuator piston being movable upstream and downstream along an axial path of travel within the interior bore of the actuator housing,

- a magnetic member mounted to and movable with the actuator piston along the axial path of travel of the actuator piston within the interior bore, the magnetic member generating a magnetic field,

- a sensor comprised of:

- a guide or a sensor housing having walls that define a chamber,

- a free floating body disposed within the guide or the chamber, the free floating body being comprised of one or more selected materials that are attracted to the magnetic field and are electrically conductive,

- the guide or the sensor housing being mounted outside the exterior surface of the actuator housing in an arrangement such that the free floating body is attracted by the magnetic field to the magnetic member and follows movement of the piston to which the magnetic member is mounted by travelling along an axial path of travel along the

guide or within the sensor housing that follows the axial path of travel of the magnetic member,

first and second electrical contacts interconnected to opposite sources of polarity that form a first circuit, the first and second electrical contacts being disposed at a selected upstream position along the axial path of travel of the free floating body, the first and second electrical contacts being arranged such that the free floating body comes into electrically conductive engagement with both the first and second electrical contacts when disposed in the selected upstream position along the path of travel of the free floating body and closes the first circuit which generates a signal indicative of the free floating body being disposed in the selected upstream position,

third and fourth electrical contacts interconnected to opposite sources of polarity that form a second circuit, the third and fourth electrical contacts being disposed at a selected downstream position along the axial path of travel of the free floating body and arranged such that the free floating body comes into electrically conductive engagement with both the third and fourth electrical contacts when disposed in the selected downstream position along the path of travel of the free floating body and closes the second circuit which generates a signal indicative of the free floating body being disposed in the selected downstream position.

[019] Preferably either the first and third electrical contacts respectively comprise selected upstream and downstream surfaces on the sensor housing or the second and fourth electrical contacts respectively comprise upstream and downstream surfaces on the sensor housing, the first and third electrical contacts being interconnected to a first source of a selected polarity and the second and fourth electrical contacts being interconnected to a second source of polarity opposite the selected polarity of the first source.

[020] The sensor housing typically comprises a hollow tube comprising an electrically conductive tubular wall, the free floating body being disposed in electrically conductive engagement with an interior surface of the tubular wall as the free floating body moves along the axial path of travel, the selected upstream position comprising an upstream interior surface of the tubular wall with which the free floating body makes electrically conductive contact and the selected downstream position comprising a downstream

interior surface of the tubular wall with which the free floating body makes electrically conductive contact.

[021] The hollow tube is preferably mounted in relation to the actuator housing such that the magnetic member attracts the free floating member into electrically conductive engagement with the interior surface of the tubular wall as the free floating member moves along the axial path of travel.

[022] The signal preferably comprises a current generated in the first or second circuits on closing of the circuits by the free floating body.

[023] The selected upstream position of the axial path of travel typically corresponds to a followed position of the piston that is a position of maximum upstream travel of the piston and interconnected valve pin.

[024] The selected downstream position of the axial path of travel typically corresponds to a followed position of the piston that is a position of maximum downstream travel of the piston and interconnected valve pin where the pin closes the gate to a mold cavity in an injection molding system.

[025] In another aspect of the invention there is provided a Method of determining the position of a piston disposed within an actuator housing in an injection molding system comprising operating the apparatus of claim 1 to move the actuator piston within the interior bore of the actuator housing and using one or more of the signals generated by the first and second circuits to determine position of the piston and the interconnected valve pin.

[026] In another aspect of the invention there is a provide an apparatus for detecting position of an actuator piston and an interconnected valve pin in an injection molding system, the apparatus comprising:

- an actuator comprising a housing having an exterior surface and an interior bore having an axis,

- the actuator piston being movable upstream and downstream along an axial path of travel within the interior bore of the actuator housing,

- a magnetic member mounted to and movable with the actuator piston along the axial path of travel of the actuator piston within the interior bore, the magnetic member generating a magnetic field,

a sensor comprised of:

a sensor housing formed as a tube comprised of an electrically conductive tubular wall defining an interior hollow channel,

a free floating body disposed within the interior chamber, the free floating body being comprised of one or more selected materials that are attracted to the magnetic field and are electrically conductive,

the tube being mounted outside the exterior surface of the actuator housing in an arrangement such that the free floating body is attracted to the magnetic member and follows movement of the piston to which the magnetic member is mounted by travelling along an axial path of travel within the interior hollow channel that follows the axial path of travel of the magnetic member along an upstream to downstream direction,

an upstream electrical contact mounted for contact with the free floating body at a selected upstream position within the interior hollow channel and a downstream electrical contact mounted for contact with the free floating body at a selected downstream position within the interior hollow channel, the upstream and downstream electrical contacts being interconnected to a first source of electricity of a selected polarity,

the electrically conductive tubular wall being interconnected to a source of electricity of opposite polarity to the selected polarity of the first source,

the upstream and downstream electrical contacts being arranged such that the free floating body comes into electrically conductive engagement with both the electrically conductive tubular wall and with a corresponding one of the upstream or downstream electrical contacts when the free floating body is disposed respectively in either the selected upstream or the selected downstream position,

the free floating body closing a first circuit when disposed in the selected upstream position and closing a second circuit when disposed in the selected downstream position, the closing of the first or second circuit generating a signal indicative of the free floating body being disposed in a corresponding one of the selected upstream or downstream positions.

[027] The tube is preferably mounted in relation to the actuator housing such that the magnetic member attracts the free floating member into electrically conductive

engagement with an interior surface of the electrically conductive tubular wall as the free floating member moves along the axial path of travel.

[028] The signal comprises a current generated in the first or second circuits on closing of the circuits by the free floating body.

[029] The selected upstream position typically corresponds to a followed position of the piston that is a position of maximum upstream travel of the piston and interconnected valve pin.

[030] The selected downstream position typically corresponds to a followed position of the piston that is a position of maximum downstream travel of the piston and interconnected valve pin.

[031] In another aspect of the invention there is provided a method of determining the position of a piston disposed within an actuator housing in an injection molding system comprising operating the apparatus of claim 9 to move the actuator piston within the interior bore of the actuator housing and using one or more of the signals generated by the first and second circuits to determine position of the piston and the interconnected valve pin.

[032] In another aspect of the invention there is provided an injection molding apparatus (1) comprising:

an injection molding machine (3), a heated manifold (40) having one or more fluid distribution channels (42), an actuator (10) interconnected to a valve pin (80), a nozzle (85) and a mold (130) having one or more mold cavities (135) wherein the injection molding machine injects an injection fluid (5) into the fluid distribution channels that deliver the injection fluid to a delivery channel (87) of the nozzle that delivers the injection fluid to the one or more mold cavities (135),

the actuator (10) comprising an actuator housing (15) having an exterior surface (15os) and an interior bore (16) having an axis (SA),

the actuator (10) including a piston (60) being movable upstream and downstream along an axial path of travel (A) within the interior bore (16) of the actuator housing (15),

a magnetic member (70) mounted to and movable with the actuator piston (60) along the axial path of travel (A) of the actuator piston (60) within the interior bore (16), the magnetic member (70) generating a magnetic field (72),

a sensor (20) comprised of:

a guide or a sensor housing (22) having walls that define a chamber (22i),

a free floating body (24) disposed within the guide or the chamber (22i), the free floating body (24) being comprised of one or more selected materials that are attracted by the magnetic field to the magnet and are electrically conductive,

the guide or the sensor housing being mounted outside the exterior surface of the actuator housing in an arrangement such that the free floating body is attracted to by the magnetic field to the magnetic member and follows movement of the piston to which the magnetic member is mounted by travelling along an axial path of travel along the guide or within the sensor housing that follows the axial path of travel of the magnetic member,

first and second electrical contacts interconnected to opposite sources of polarity that form a first circuit, the first and second electrical contacts being disposed at a selected upstream position along the axial path of travel of the free floating body, the first and second electrical contacts being arranged such that the free floating body comes into electrically conductive engagement with both the first and second electrical contacts when disposed in the selected upstream position along the path of travel of the free floating body and closes the first circuit which generates a signal indicative of the free floating body being disposed in the selected upstream position,

third and fourth electrical contacts interconnected to opposite sources of polarity that form a second circuit, the third and fourth electrical contacts being disposed at a selected downstream position along the axial path of travel of the free floating body and arranged such that the free floating body comes into electrically conductive engagement with both the third and fourth electrical contacts when disposed in the selected downstream position along the path of travel of the free floating body and closes the second circuit which generates a signal indicative of the free floating body being disposed in the selected downstream position.

[033] Typically in such an apparatus, either the first and third electrical contacts respectively comprise selected upstream and downstream surfaces on the sensor housing or the second and fourth electrical contacts respectively comprise upstream and downstream surfaces on the sensor housing, the first and third electrical contacts being interconnected to a first source of a selected polarity and the second and fourth electrical contacts being interconnected to a second source of polarity opposite the selected polarity of the first source.

[034] The sensor housing preferably comprises a hollow tube comprising an electrically conductive tubular wall, the free floating body being disposed in electrically conductive engagement with an interior surface of the tubular wall as the free floating body moves along the axial path of travel, the selected upstream position comprising an upstream interior surface of the tubular wall with which the free floating body makes electrically conductive contact and the selected downstream position comprising a downstream interior surface of the tubular wall with which the free floating body makes electrically conductive contact.

[035] The hollow tube is preferably mounted in relation to the actuator housing such that the magnetic member attracts the free floating member into electrically conductive engagement with the interior surface of the tubular wall as the free floating member moves along the axial path of travel.

[036] The signal typically comprises a current generated in the first or second circuits on closing of the circuits by the free floating body.

[037] The selected upstream position of the axial path of travel typically corresponds to a followed position of the piston that is a position of maximum upstream travel of the piston and interconnected valve pin.

[038] The selected downstream position of the axial path of travel typically corresponds to a followed position of the piston that is a position of maximum downstream travel of the piston and interconnected valve pin.

[039] In another aspect of the invention there is provided a method of determining the position of a piston disposed within an actuator housing in an injection molding apparatus according to claim 15 comprising moving the actuator piston within the interior bore of the actuator housing and using one or more of the signals generated by

the first and second circuits to determine position of the piston and the interconnected valve pin.

Brief Description of the Drawings

[040] The above and further advantages of the invention may be better understood by referring to the following description in conjunction with the accompanying drawings in which:

[041] Fig. 1 is a cross-sectional view of an injection molding system according to the invention comprised of an injection machine, a hotrunner or manifold with associated actuator, valve pin, top clamp plate, nozzle, mold 130, 131 and mold cavity 135, the system including one embodiment of a valve pin position sensor device 20 where the position sensor is mounted on the outside surface of an actuator and the travelling or floating electrically conductive ball component is disposed in its most downstream position in contact with a downstream electrical contact completing a circuit that generates a signal indicative of the downstream position of an actuator piston that the ball is following.

[042] Fig. 2 is a schematic cross-sectional view of the position sensor device, actuator, manifold and mold components of the system of Fig. 1 showing the electrically conductive ball in its most downstream position.

[043] Fig. 2A is a cross-section view taken along lines 2A-2A of Fig. 2 of the position sensor device component of the system of Fig. 1 showing the electrically conductive ball in its most downstream position.

[044] Fig. 3 is a schematic cross-sectional view of the position sensor device, actuator, manifold and mold components of the system of Fig. 1 showing the electrically conductive ball in its most upstream position.

[045] Fig. 3A is a cross-section view taken along lines 3A-3A of Fig. 3 of the position sensor device component of the system of Fig. 1 showing the electrically conductive ball in its most upstream position.

[046] Fig. 4 is a circuit diagram showing one embodiment of a pair of circuits corresponding to the two circuits that the ball component of the position sensor of

shown in Figs 1-9 is a part of, the ball component corresponding to the switches S1, S2 of the two circuits shown.

[047] Fig. 5A is a side schematic sectional view of the position detector component of the system of Fig. 1 showing the electrically conductive ball in its most downstream position and a diode 210d being activated when the ball is in the shown position.

[048] Fig. 5B is a side schematic sectional view of the position detector component of the system of Fig. 1 showing the electrically conductive ball in its most upstream position and a diode 220d being activated when the ball is in the shown position.

[049] Fig. 6 is a side sectional view of the position sensor component of the apparatuses shown in Figs. 1-5B mounted on the side of the actuator of the system of claim 1.

[050] Fig. 7 is a front sectional view taken along lines 7-7 of Fig. 6 showing the position sensor component of the apparatuses shown in Figs. 1-6 mounted on the side of the actuator of the system of claim 1 showing the electrically conductive and magnetic ball of the sensor being magnetically attracted to and following the position of a magnet member 70 mounted on the piston of the actuator where the ball, the piston and its associated magnet member are all disposed in their fully upstream positions.

[051] Fig. 8 is a side sectional view of another embodiment of a position sensor 20 mounted on the side of the housing of an actuator used in a system similar to the system of Fig. 1 where the sensor 20 comprises discrete electrically conductive contacts 160, 170 mounted and disposed at discrete positions between the upstream 50u and downstream 50d opposite polarity contacts such that the ball 20 makes contact with the electrically conductive contacts 160 170 at only the discrete positions as opposed to making continuous electrical contact with the conductive tubular wall 28 at all positions between the upstream 50u and downstream 50d contacts.

[052] Fig. 9 is a front sectional view taken along lines 9-9 of Fig. 8 showing the position sensor component of Fig. 8 mounted on the side of the actuator of the system of claim 1 showing the electrically conductive and magnetic ball of the sensor being magnetically attracted to and following the position of a magnet member 70 mounted on

the piston of the actuator where the ball, the piston and its associated magnet member are all disposed in their fully upstream positions and in contact with the discretely upstream positioned negative polarity contact 160.

Detailed Description

[053] Figure 1 shows in schematic cross-section an injection molding system 1 comprised of an injection machine having an injection barrel 3 that injects a selected fluid 7 into the channel of an inlet 5 that communicates with a fluid distribution channel 42 of a heated manifold or hotrunner 40. The system 1 typically further comprises a top clamp plate 13 that is mounted and interconnected to a mold 130, 131 and a manifold 40 that is disposed between the top clamp plate 13 and the mold 130, 131. A hydraulically or pneumatically powered actuator 10 is typically mounted on or to either the top clamp plate 13 or the manifold 40. A valve pin 80 is interconnected to the downstream end of the piston 60 and is adapted to be reciprocally driven in an upstream-downstream direction UD along axis A. The pin 80 has a downstream distal tip end 88 that is driven between a gate 90 closed position when the piston 60 is in a downstream-most position as shown in Figs. 1, 2, 2A, 5A, 6, 8 and an upstream gate 90 open position when the piston is driven upstream from the gate closed toward the upstream-most position of the piston 60 as shown in Figs. 3, 3A, 5B, 7, 9. The tip end 88 of the pin 80 is configured to be complementary in shape, contour or configuration such that when the piston is driven to its downstream-most position, the tip end 88 seals or closes the gate 90 such that fluid 7 cannot flow into the cavity 135 of the mold 130, 131.

[054] With reference to Figs. 1-6, the actuator is comprised of a housing 15 having a position sensor 20 mounted on a radial outside surface 15os of the housing 20. The sensor 20 comprises an elongated tube 22 having a continuous elongated upstream to downstream electrically conductive wall 28 and an interior hollow tubular channel 22i in which is disposed a free floating electrically conductive and magnetically active member 24 shown in the figures in the form of a spherical free floating ball 24. The member 24 is comprised of a material that is magnetic or otherwise magnetically forcibly attracted to a

magnet field 72. In the embodiment shown in Figs. 1-6, the actuator housing 15 is slidably mounted on an axial positioning mount 12 that is in turn mounted on a mount mechanism 14 that is in turn mounted on the heated manifold 40, Fig. 1-3 of the injection molding system 1.

[055] As shown in Figs. 1, 2A, 5A, 6 the spherical ball 24 is disposed in its downstream-most position in electrically conductive contact with both the interior wall surface 22is of the tube 22 and wall 28 and also simultaneously in electrically conductive contact with a downstream mounted electrical contact 50d such that an electrical circuit 210 is completed to activate a diode 210d, Fig. 5A. The tube 22 and wall 28 is typically comprised of an electrically conductive material such as a metal comprised of one or more materials such as copper, iron or a polymer containing an electrically conductive material such as graphite or the like. The tube 22 is interconnected to the ground or negative (-) terminal 200i of a source 200 of electricity, Fig. 4, 5A, 5B. The downstream contact 50d is interconnected to the positive 200p terminal of the source of electrical energy 200. In the downstream contact position shown in Figs. 1, 2A, 5A, 6, the free floating ball 24 acts as the switch S2 of Figs. 4, 5A, 5B completing the circuit 210 to activate the diode 210d via current limiting resistor 230 that generates a current that can activate an LED activated light associated with diode 210d such as shown in Fig. 5A to visually indicate by color green that the piston 60 of the actuator 10 is disposed in a downstream-most valve pin, gate closed position as shown in Figs. 1, 2A, 5A, 6 and Fig. 8. The diodes 210d, 220d are typically housed in a housing 300 and mounted such that the visible generated by the diodes 210d, 220d is readily visually observable from the exterior of the housing or box 300.

[056] Figs 3, 3A, 5B, 7 show the ball 24 in its upstream-most position in electrically conductive contact with both the interior wall surface 21is of the tube 22 and wall 28 and in electrically conductive contact with an upstream mounted electrical contact 50u. As shown the free floating conductive member 24 makes electrically conductive contact with the interior surface 21is at one or more discrete conductive surfaces 21c disposed along the interior surface 21is of the tube 22, 28 such that current flows through one or the other of the circuits 210, 220 when the member 24 is in either the upstream-most or downstream-most position as described herein.

[057] The upstream contact 50u is interconnected to the positive 200p terminal of the source of electrical energy 200. In the upstream contact position shown in Figs. 3, 3A, 5B, 7, 9 the free floating ball 24 acts as the switch S1 in Fig. 4 completing the circuit 220 to activate the diode 220d via current limiting resistor 230 that generates a current that can activate an LED activated light associated with diode 220d, Fig. 5B to visually indicate by color red that the piston 60 of the actuator 10 is disposed in the upstream-most valve pin, gate open position as shown in Figs. 3, 3A, 5B, 7.

[058] A magnet 70 that generates a magnetic field 72, Fig. 5A, 5B, 7, 9 of a strength sufficient to physically attract and carry along and move the ball 24 along and through the tube axis SA is mounted to the piston 60 such that the magnet 70 travels axially A together with the piston 60 for reciprocal axial upstream and downstream movement A within the interior bore 16 that is formed within the actuator housing 15. As shown, Figs. 1-3, 5A, 5B, 7 the sensor tube or housing 22 is mounted and arranged relative to the piston 60 and magnet 70 such that the ball 24 is disposed in a physical proximity to the magnet 70 such that the ball 24 is physically attracted to, carried along with and influenced by the magnetic field 72 generated by the magnet 70 mounted to the piston 60 of the actuator.

[059] The free floating member or ball 24 can be configured into any geometrical shape that fits complementarily within the interior channel 22i of the electrically conductive tube 22 such as oval, square, parallelepiped, box-like or the like as long as the shape of the member 24 is sufficient to make effective electrically conductive contact with the interior surface 22is of the tube 22. The ball or other free floating body 24 is comprised of a material that is both electrically conductive and is attracted to a magnetic field such as iron, nickel, cobalt, graphite and certain other rare earth metal materials. The material of which the free floating member 24 is comprised is not necessarily and preferably is not a magnet itself, namely does not necessarily generate its own magnetic field as does magnet 70.

[060] The term “free floating” or “free floating body” is meant to refer to a body of material that is not mechanically attached or connected to any other member or component of the system such that the body 24 can follow and move without restriction with the movement of the magnet 70 under the attractive force of the magnetic field 72.

[061] As shown in Figs. 8, 9, the mechanism by which the free floating member 24 is mounted on the outside surface 15os of the actuator housing 15 does not necessarily have to be in the form of a continuous tube 28 that completely houses the ball 24. In order for the electrically conductive body or member 24 to act as a switch S1 to close circuit 220, there are provided first 50u and second 160 upstream disposed electrical contacts that are interconnected to opposite polarity 200p and 200i sources of electrical energy. The upstream electrical contacts 160, 170 can comprise a separate and discrete elements or structures disposed between the upstream and downstream contacts 50u, 50d as opposed to a continuous elongated tube 28 wall or other component as shown in Figs. 1-7. The contacts 50u, 160 and must be mounted, arranged or disposed in a preselected upstream position UP and arrangement that is complementary to the predetermined or preselected upstream position UPS of the free floating body 24 such that the body 24 can simultaneously make electrically conductive contact with both of the contact points or surfaces 168, 160s of the first and second upstream electrical contacts 50u, 160. Similarly, in order for the electrically conductive body or member 24 to act as a switch S2 to close circuit 210, third 50d and fourth 170 electrical contacts are interconnected to opposite polarity 200p and 200i sources of electrical energy and are mounted, arranged or disposed in a preselected downstream position DP that is complementary to the preselected downstream position DPS of the floating body 24 such that the floating body 24 can simultaneously make electrically conductive contact with the contact points or surfaces 172, 170s of the third and fourth downstream electrical contacts 50d, 170. The contacts 160, 170 can be formed as separate structures or elements apart from a continuous tube 22 structure and each contact 160, 170 can be separately interconnected to a source of electricity or ground 200i opposite in polarity to the source 200p that is connected to contacts 50u, 50d.

[062] As shown, the positive electrical contacts 50u, 50d are mounted by electrical insulators 30 to the upstream and downstream ends of tube 22 or ramp 25 in an arrangement such that the electrically conductive member 24 is readily electrically conductively engageable with a contact surface 50us, 50ds of the contacts 50u, 50d when the member 24 is mechanically moved by the magnet 70 and field 72 to the upstream-most and downstream-most positions as described herein.

[063] Figs. 8, 9 shows an embodiment where the free floating, electrically conductive ball 24 rides axially SA along a guide or rail 25 or the like between the upstream 50u and downstream 50d electrically conductive contact points that are connected to a positive source of charge. The guide or rail 25 is interconnected to ground or negative 200i source, Fig. 4. As in the above-described embodiments contacts 160, 170 can be formed as separate, discrete structural components of the guide or rail 25, or can comprise separate and discrete components independent of a larger structure. Each contact 160, 170, Figs. 8, 9 is electrically connected to a ground or negative source 200i, Fig. 4, that is opposite in polarity to the source 200p that is interconnected to contacts 50u and 50d.

What is claimed is:

1. An apparatus for detecting position of an actuator piston (60) and an interconnected valve pin (80) in an injection molding system (1), the apparatus comprising:
 - an actuator (10) comprising an actuator housing (15) having an exterior surface (15os) and an interior bore (16) having an axis (SA),
 - the actuator piston (60) being movable upstream and downstream (UD) along an axial path of travel (A) within the interior bore (16) of the actuator housing (15),
 - a magnetic member (70) mounted to and movable with the actuator piston (60) along the axial path of travel (A) of the actuator piston within the interior bore (16), the magnetic member (70) generating a magnetic field (72),
 - a sensor (20) comprised of:
 - a free floating body (24) comprised of one or more selected materials that are attracted to the magnetic field (72) and are electrically conductive,
 - a guide (25) or a sensor housing (22) having one or more electrically conductive surfaces (21is, 160, 170) that define an upstream to downstream path of travel for the free floating body (24) and are interconnected to a first source of electrical polarity (200i),
 - the free floating body (24) being held by the magnetic member (70) in electrically conductive contact with the one or more electrically conductive surfaces (21is, 160, 170),
 - the guide (25) or sensor housing (22) being mounted outside the interior bore (16) of the actuator housing (15) in an arrangement such that the free floating body (24) is attracted to the magnetic member (70) and follows movement of the piston (60) to which the magnetic member (70) is mounted by travelling along the upstream downstream path of travel of the free floating body (24),
 - first (50u) and second 50d) electrical contacts being interconnected to a second source (200p) of electrical polarity that is opposite the polarity of the first source, the first and second electrical contacts being disposed respectively at first and second

selected upstream and downstream positions along the path of upstream to downstream travel of the free floating body (24),

the first selected upstream position being selected such that the free floating body (24) comes simultaneously into electrically conductive engagement with the first electrical contact (50u) and one of the electrically conductive surfaces (21is, 160) to form a first circuit (220) when the free floating body is disposed in the selected upstream position along the upstream to downstream path of travel,

the second selected downstream position being selected such that the free floating body (24) comes simultaneously into electrically conductive engagement with the second electrical contact (50d) and one of the electrically conductive surfaces (21is, 170) to form a second circuit (210) when the free floating body is disposed in the selected downstream position along the upstream to downstream path of travel.

2. The apparatus of claim 1 wherein the sensor housing comprises a hollow tube (22) comprised of an electrically conductive material, the free floating body (24) being disposed within a channel (22i) of the tube having an interior electrically conductive surface (21is) with which the free floating body makes electrically conductive contact under magnetic force (72) exerted by the magnet (70) that is mounted on the piston. (60).

3. The apparatus of according to any of the preceding claims wherein the guide is mounted in relation to the actuator housing such that the magnetic member (70) attracts the free floating member (24) into electrically conductive engagement with the electrically conductive surface (160, 170) of the tubular wall when the free floating member is disposed in either the selected upstream position or the selected downstream position.

4. The apparatus according to any of the preceding claims wherein an observable signal is generated on formation of first and second circuits.

5. The apparatus according to any of the preceding claims wherein the selected upstream position of the upstream to downstream path of travel corresponds to a followed position of the piston that is a position of maximum upstream travel of the piston and interconnected valve pin.
6. The apparatus according to any of the preceding claims wherein the selected downstream position of the upstream to downstream path of travel corresponds to a followed position of the piston that is a position of maximum downstream travel of the piston and interconnected valve pin.
7. The apparatus according to any the preceding claims wherein the free floating member is configured generally as a sphere.
9. Method of determining the position of a piston disposed within an actuator housing in an injection molding system, comprising operating an apparatus according to any of the preceding claims to move the actuator piston between a gate closed position and an upstream position such that the first and second circuits are formed during the course of an injection cycle.
8. An injection molding system (1), comprising:
 - a manifold (40), an injection molding machine having a barrel (3) that delivers injection fluid (7) to a fluid distribution channel (42) of the manifold (40), a mold (130, 131) forming a cavity (135),
 - an actuator (10) comprising an actuator housing (15) having an exterior surface (15os) and an interior bore (16) having an axis (SA),
 - the actuator piston (60) being movable upstream and downstream (UD) along an axial path of travel (A) within the interior bore (16) of the actuator housing (15),
 - a magnetic member (70) mounted to and movable with the actuator piston (60) along the axial path of travel (A) of the actuator piston within the interior bore (16), the magnetic member (70) generating a magnetic field (72),
 - a sensor (20) comprised of:

a free floating body (24) comprised of one or more selected materials that are attracted to the magnetic field (72) and are electrically conductive,

a guide (25) or a sensor housing (22) having one or more electrically conductive surfaces (21is, 160, 170) that define an upstream to downstream path of travel for the free floating body (24) and are interconnected to a first source of electrical polarity (200i),

the free floating body (24) being held by the magnetic member (70) in electrically conductive contact with the one or more electrically conductive surfaces (21is, 160, 170),

the guide (25) or sensor housing (22) being mounted outside the interior bore (16) of the actuator housing (15) in an arrangement such that the free floating body (24) is attracted to the magnetic member (70) and follows movement of the piston (60) to which the magnetic member (70) is mounted by travelling along the upstream downstream path of travel of the free floating body (24),

first (50u) and second (50d) electrical contacts being interconnected to a second source (200p) of electrical polarity that is opposite the polarity of the first source, the first and second electrical contacts being disposed respectively at first and second selected upstream and downstream positions along the path of upstream to downstream travel of the free floating body (24),

the first electrical contact (50u) being arranged relative to the one or more electrically conductive surfaces (21is, 160, 170) such that the free floating body (24) comes simultaneously into electrically conductive engagement with the first electrical contact (50u) and one of the electrically conductive surfaces (21is, 160) to form a first circuit (220) when the free floating body is disposed in the selected upstream position along the upstream to downstream path of travel,

the second electrical contact (50d) being arranged relative to the one or more electrically conductive surfaces (21is, 160, 170) such that the free floating body (24) comes simultaneously into electrically conductive engagement with the second electrical contact (50d) and one of the electrically conductive surfaces (21is, 170) to form a second circuit (210) when the free floating body is disposed in the selected downstream position along the upstream to downstream path of travel.

9. The system according claim 8 wherein the sensor housing comprises hollow tube (22) comprised of an electrically conductive material, the free floating body (24) being disposed within a channel (22i) of the tube having an interior electrically conductive surface (21is) with which the free floating body makes electrically conductive contact under magnetic force (72) exerted by the magnet (70) that is mounted on the piston. (60).

10. The system according to any of claims 8 or 9 wherein the guide is mounted in relation to the actuator housing such that the magnetic member (70) attracts the free floating member (24) into electrically conductive engagement with the electrically conductive surface (160, 170) of the tubular wall when the free floating member is disposed in either the selected upstream position or the selected downstream position.

11. The system according to any of claims 8-10 wherein an observable signal is generated on formation of first and second circuits.

12. The system according to any of claims 8-11 wherein the selected upstream position of the upstream to downstream path of travel corresponds to a followed position of the piston that is a position of maximum upstream travel of the piston and interconnected valve pin.

13. The system according to any of claims 8-12 wherein the selected downstream position of the upstream to downstream path of travel corresponds to a followed position of the piston that is a position of maximum downstream travel of the piston and interconnected valve pin.

14. Method of determining the position of a piston disposed within an actuator housing in an injection molding system comprising operating a system according to any of claims 8-13 to move the actuator piston between a gate closed position and an

upstream position such that the first and second circuits are formed during the course of an injection cycle.

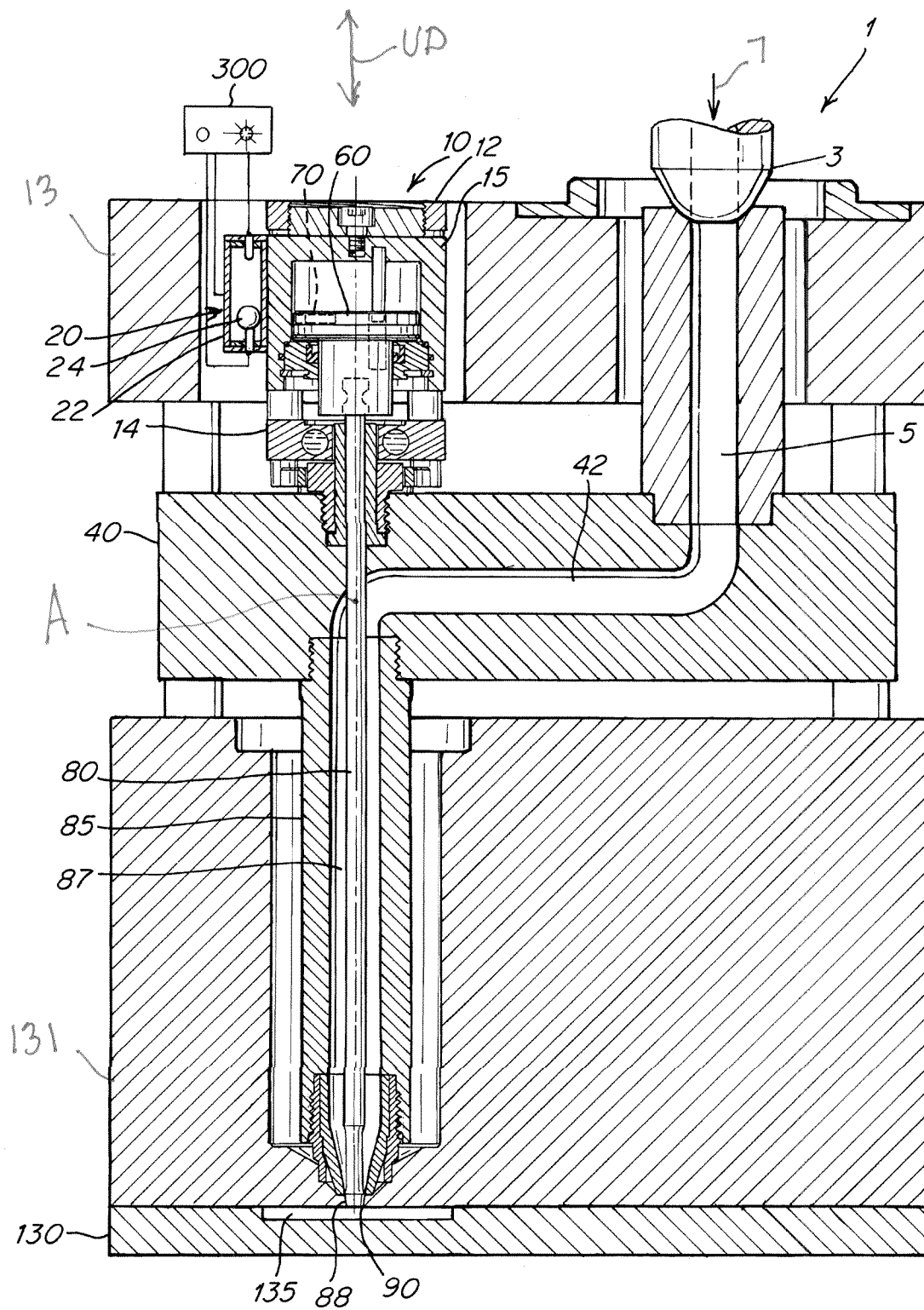
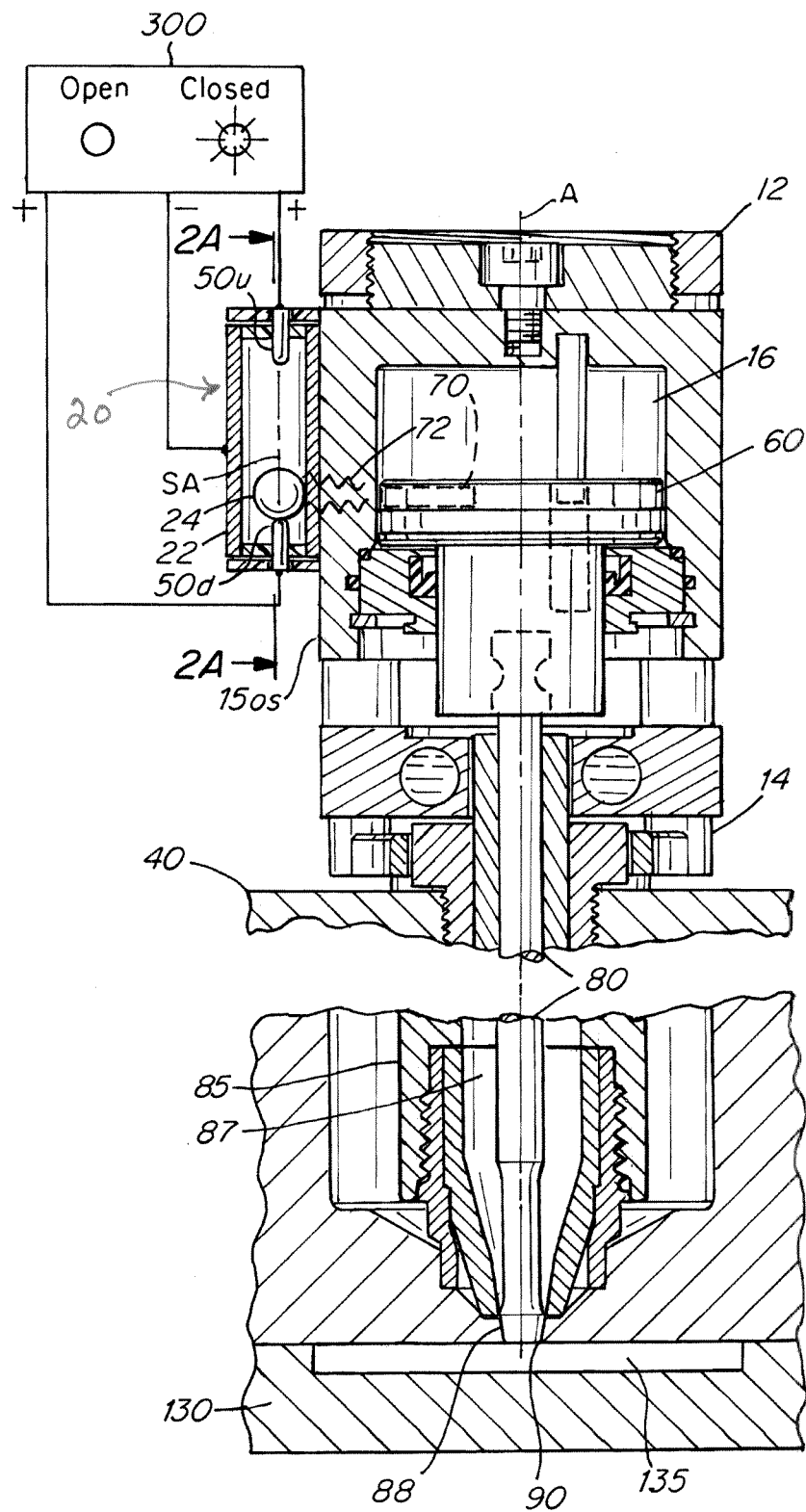


Fig. 1

**Fig. 2**

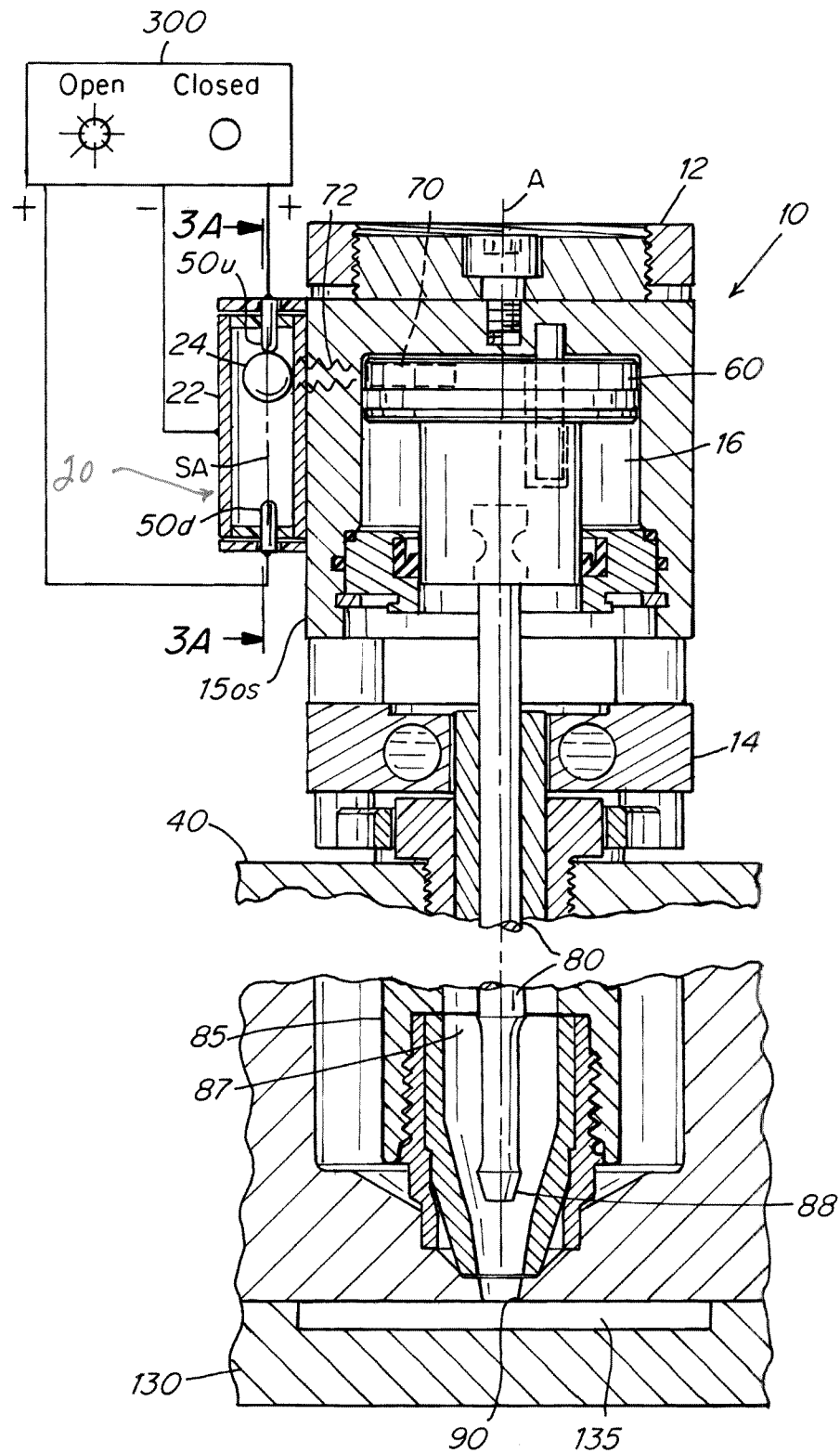


Fig. 3

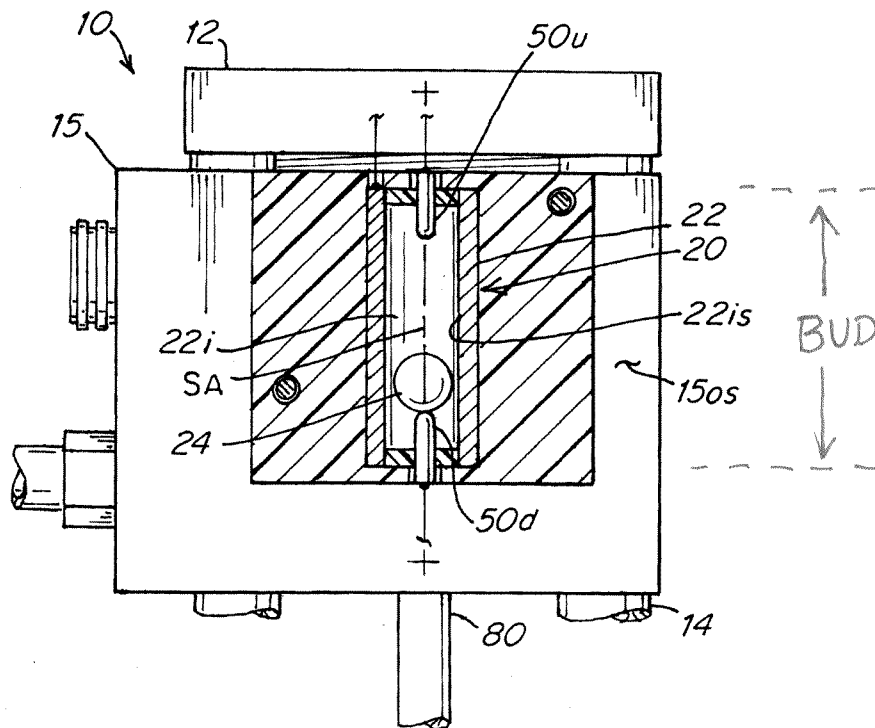


Fig. 2A

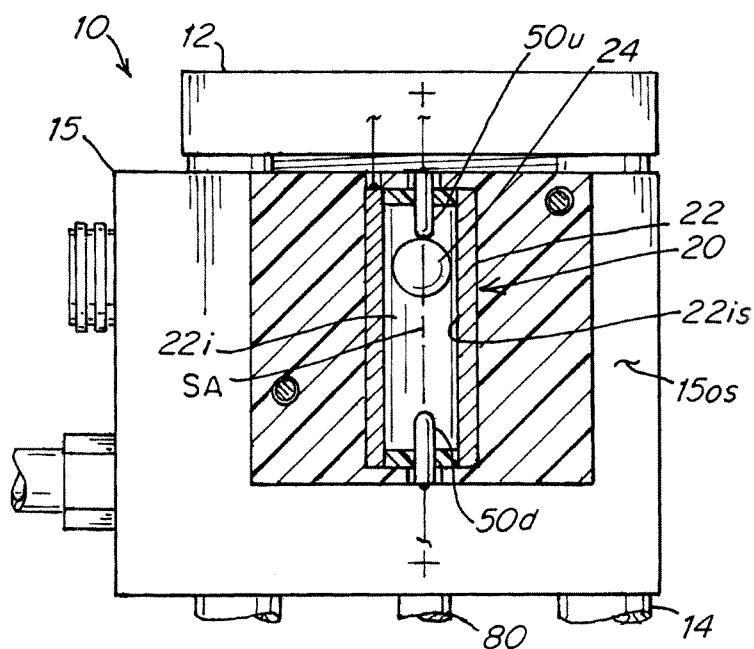


Fig. 3A

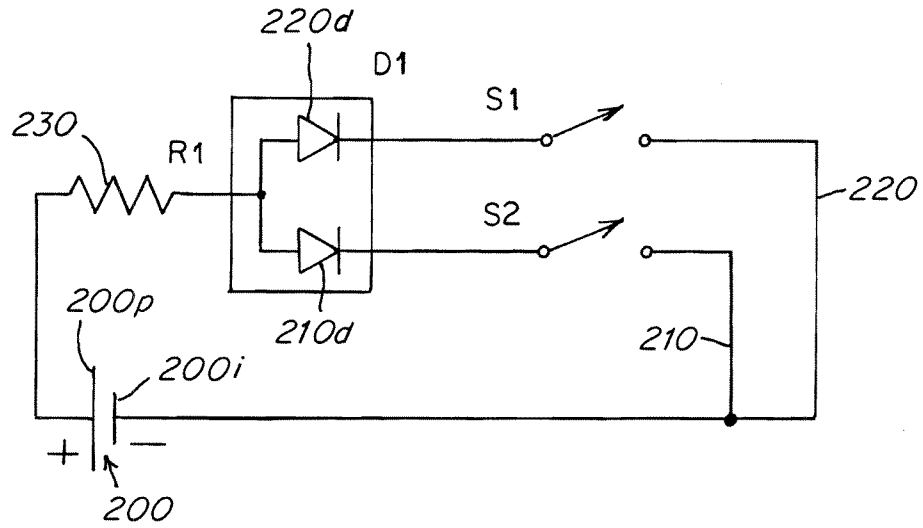


Fig. 4

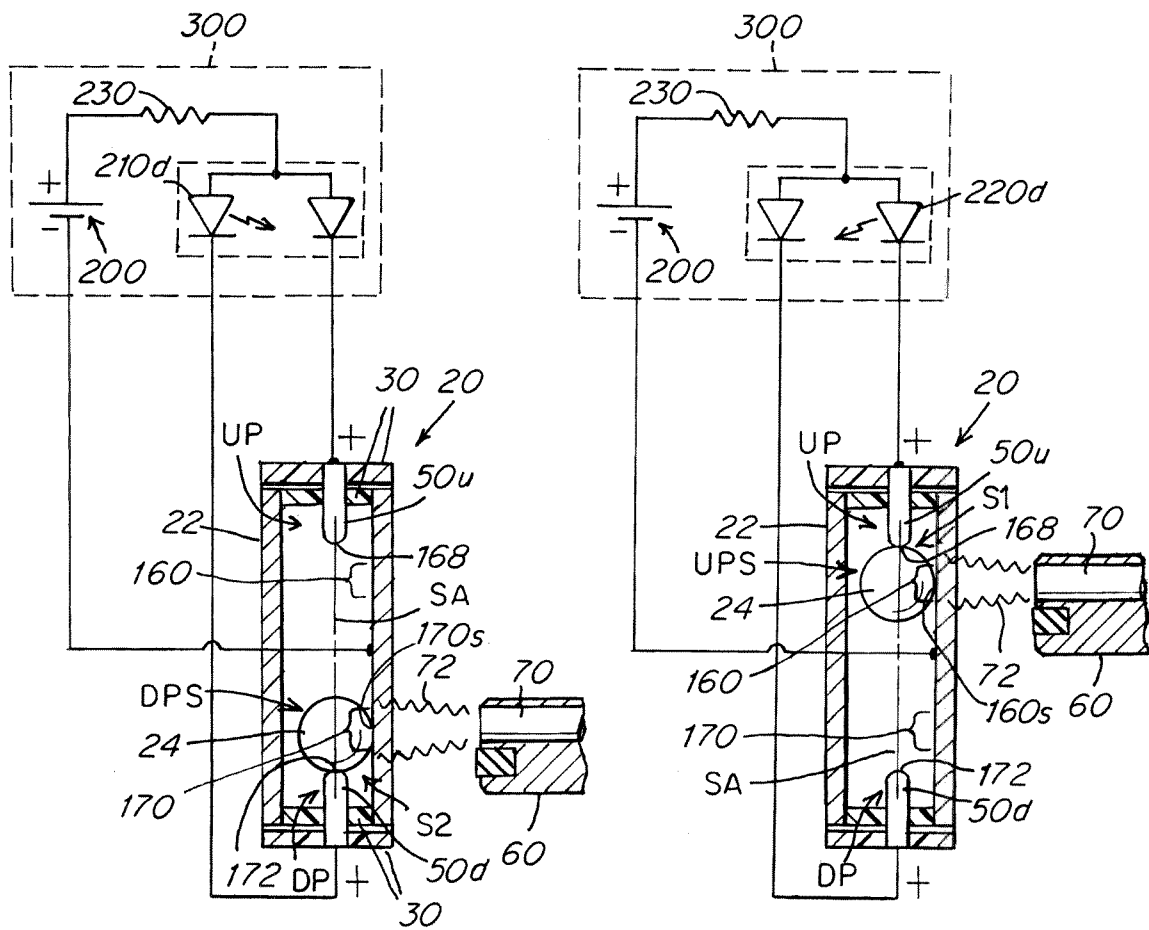


Fig. 5A

Fig. 5B

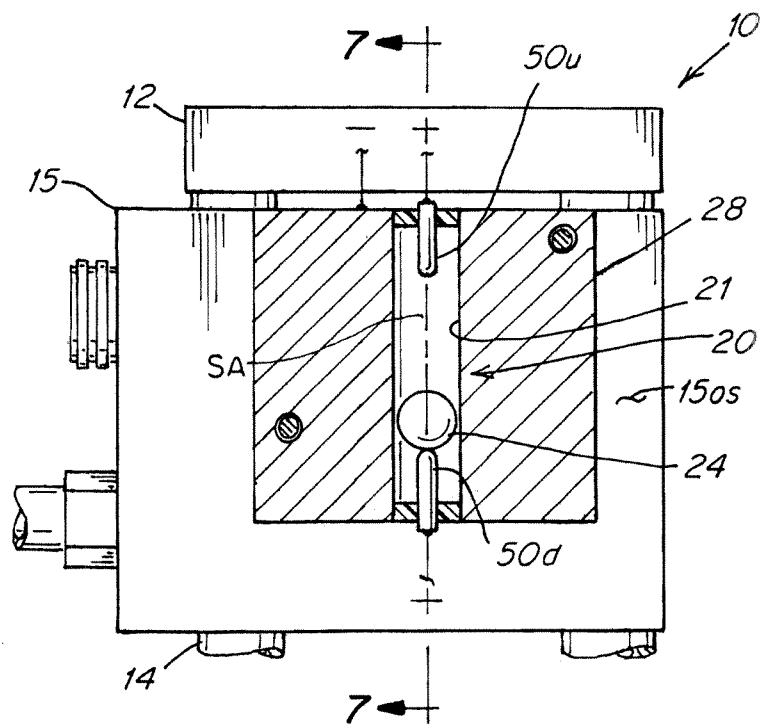


Fig. 6

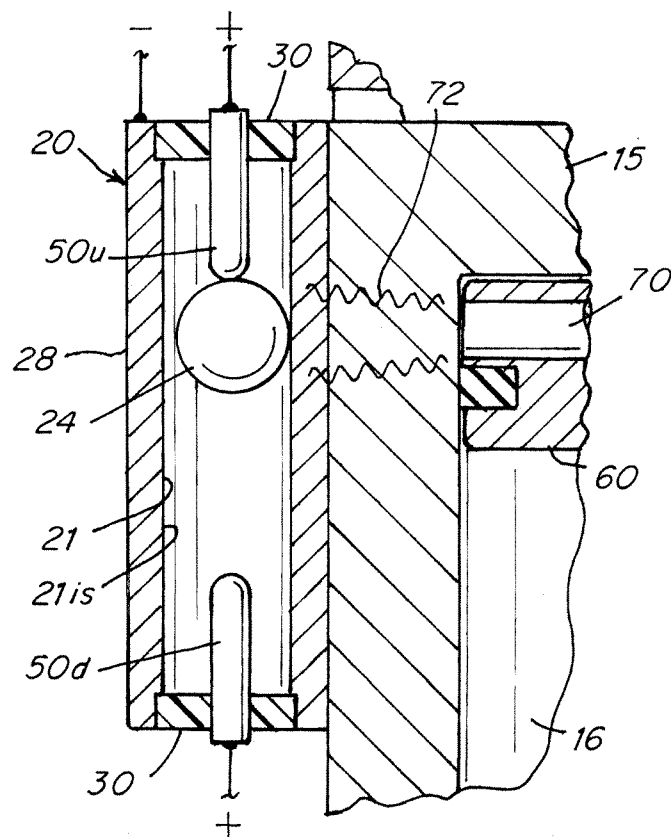


Fig. 7

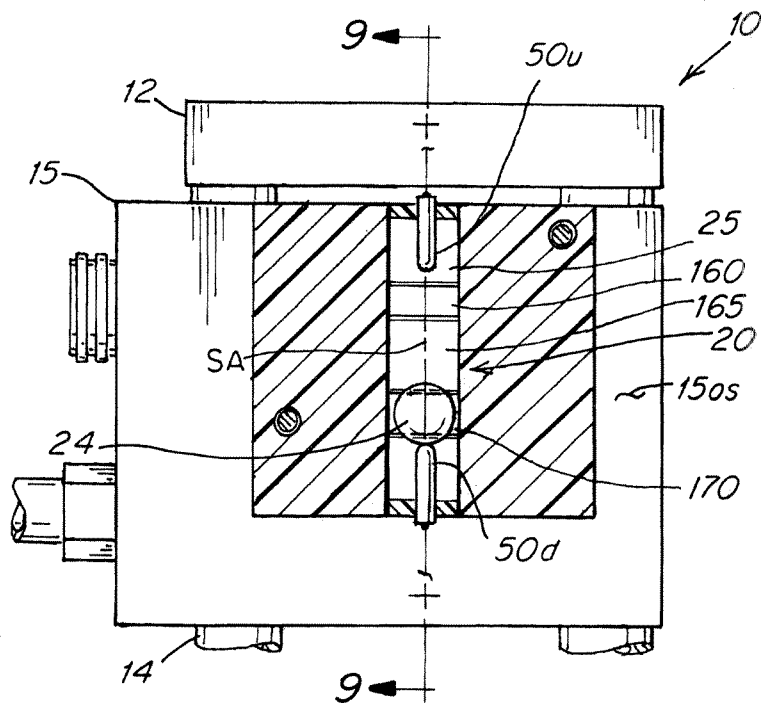


Fig. 8

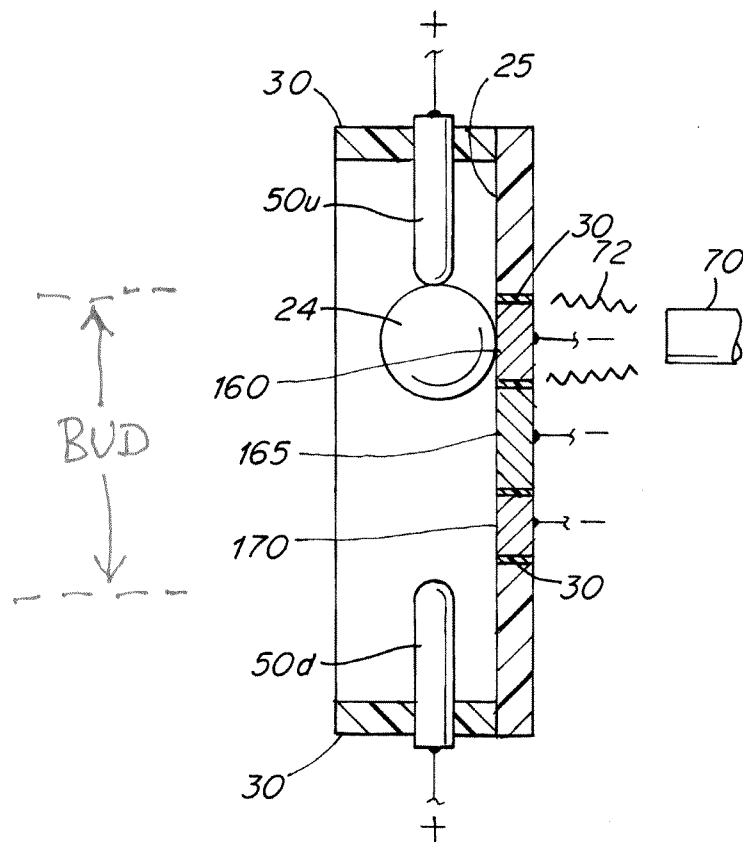


Fig. 9

INTERNATIONAL SEARCH REPORT

International application No

PCT/US2016/032643

A. CLASSIFICATION OF SUBJECT MATTER

INV. B29C45/28

ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

B29C F15B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 2014/035563 A1 (TAN ZHUANG RUI [US] ET AL) 6 February 2014 (2014-02-06) abstract; figures 1-7 paragraphs [0066] - [0080] -----	1-14
A	US 2003/111004 A1 (ENZAKI AKIRA [JP] ET AL) 19 June 2003 (2003-06-19) paragraphs [0022] - [0031] paragraphs [0037] - [0042] figures 1-7 -----	1
A	US 2008/211522 A1 (MOHR GODRAM [CH] ET AL) 4 September 2008 (2008-09-04) cited in the application abstract; figures 1-9 paragraphs [0034] - [0044] paragraph [0048] -----	1



Further documents are listed in the continuation of Box C.



See patent family annex.

* Special categories of cited documents :

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Date of the actual completion of the international search

25 January 2017

Date of mailing of the international search report

02/02/2017

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Authorized officer

Gemeinböck, Gerald

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/US2016/032643

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